NOTES ON THE MORPHOLOGY AND BIOLOGY OF *CAENOPROSOPON TRICHOCERUS* (BIGOT). (DIPTERA, TABANIDAE, PANGONIINAE.)

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(Fifteen Text-figures.)

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Synopsis.

The larva and pupa of *Caenoprosopon trichocerus*, collected at Epping, N.S.W., are described and figured. Immature stages are known of only one other species, *Ectenopsis angusta* (Macq.), of the Tribe Pangoniini. The larva and pupa of both species have characters which distinguish them from other Tabanidae, but they can also be readily distinguished from one another.

Introduction.

This species was described by Bigot (1892) as *Corizoneura trichocera*, and the genus *Caenoprosopon* was erected by Ricardo (1915). The adults are more fully described by Mackerras (1956). The immature stages of only one other species of the tribe are known, *Ectenopsis* (*Ectenopsis*) *angusta* (Macq.) (English, 1953), and the larva and pupa described in this paper resemble those of *Ectenopsis* in many characters which distinguish them from other Tabanidae.

Occurrence.

A number of larvae and some pupae were found near Epping, New South Wales, at various times between 1919 and 1936 by Mr. Luke Gallard, then Fruit Inspector of the N.S.W. Department of Agriculture, who lived and worked in the district. Mr. A. Musgrave of the Australian Museum, Sydney, in his Bibliography of Ausralian Entomology (1932) says of Mr. Gallard: "He was an economic entomologist who has done good work in investigating the life-histories of insects."

For many years Mr. Gallard kept a detailed diary of his work and his collecting, often with notes on the locality and situation of his finds. After his death in March, 1938, his diary (in several books) was given to the Australian Museum, where I was able to read it in 1960.

He was always on the lookout for insect larvae, and in 1917 he began to search particularly for the larvae of *Ithone* (Tillyard, 1919 and 1922), an unusual neuropteran, in which Tillyard was greatly interested at that time. In 1918 they found the first larva of *Ithone* at Woy Woy, N.S.W., and it was during the search for these larvae in subsequent years, mostly at Epping, that he found the larvae of *Caenoprosopon*, and apparently the two species were often associated.

The locality in which the pupae and most of the larvae were found he calls "Cadell's Creek", evidently a local name for part of Terry's Creek, for in the diary is a small locality sketch with a bridge in Pembroke Street marked "Cadell's Bridge", and heavy timbers of this bridge still remain beside the new concrete bridge over Terry's Creek on the Epping Highway which cuts Pembroke Street just there.

Few people now remember the name, but two residents could tell me that a family named Cadell lived near Pembroke Street, east of the creek, and they had fruit trees on their land near the creek, so Gallard's "Cadell's Creek" is probably part of Terry's Creek south of Epping Highway, where Cadell's land came down; a narrow reserve now follows the creek from the old bridge to Dence Park.

In the diary he refers always to the *Caenoprosopon* larvae as "ribbed fly larvae", presumably because the abdominal pseudopods are quite prominent, and this would distinguish them from other tabanid larvae he knew, species of *Scaptia* and *Dasybasis*, in which the abdominal pseudopods are scarcely noticeable.

The first entries that I found in the diary relating to these larvae were very short. "Sept. 2, 1919. Got three more *Ithone* larvae. Another ribbed fly." "Sept. 3, 1919. Got four more *Ithone* larvae about 15 inches under the surface in yellow sand and one more ribbed fly larva." "Oct. 21, 1919. Got three more ribbed fly larvae from soil about 6 inches deep . . . and *Ithone* larvae about 18 inches deep." Other entries in the diary about this time record finds of the fly larvae, but, except the first, I have only quoted those giving details of situation in the soil.

Some of the later entries are fuller and most larvae found at Epping were "in the gully through which runs Cadell's Creek" usually within about six yards of the creek. "Nov. 15, 1930. At Cadell's Creek got three fair sized ribbed fly larvae . . . they were close to the surface. The three were within one square yard." On September 11, 1934, Miss V. Irwin Smith of Woolwich, N.S.W., went with Mr. Gallard, and she wrote: "About eight feet above the creek bank he cut with a pick into the hard earth of a small embankment . . . and on breaking up the heavy clods of earth taken from a foot or two below the surface of the path found a ribbed larva firmly embedded and encrusted with dirt. The earth was damp following several weeks of heavy rain, but Mr. Gallard says it is usually dry and hard."

Again quoting the diary. "Sept. 23, 1936. I got ten *Ithone* larvae and ten pupae also four ribbed fly larvae. The ground was dry and hard, they were in a place where the top soil had been removed two years ago." He had found some of the fly larvae near Pittwater, N.S.W., where he went to prune fruit trees; he wrote: "July 23, 1934. At Pittwater I dug in the soil just outside the cowyard and secured . . . four large ribbed Tab. larvae like those taken at Epping. The soil is rich black loam with small rubble stones."

A number of larvae were obtained from Mr. Gallard by Miss Irwin Smith between 1919 and 1936, and from her own notes, or from data given her by Mr. Gallard, she had records of 22 larvae. Of these: 1 was injured in collecting; it died, and was preserved; 5 were killed and preserved soon after collecting; 3 escaped; 1 lived for 10 months, and there is no further record; 9 lived for periods varying from 3 to 28 months, then died; 2 pupated after 3 months and 16 months, and died as pupae; 1 began to pupate within two days of collection, but it failed to shed the larval exuvia, and died as a pupa.

Two pupae had been collected in 1932, one in January and one in March, and from these adults emerged. The only other pupa found was in February, 1920, and it died without emerging.

Mr. Gallard kept some larvae and one imago; Miss Irwin Smith kept some larvae and one ♀ imago which Mr. F. H. Taylor identified for her in 1933 as *Demoplatus trichocerus* (Bigot), and in 1958 she gave me her material. In 1959 Dr. I. M. Mackerras confirmed the identification as *Caenoprosopon trichocerus* (Bigot), *Demoplatus* having become a synonym.

The larvae are carnivorous, and apparently fed readily in captivity, but the record above suggests that they are difficult to rear to maturity.

One other record is of a larva collected by the author at Pymble, N.S.W., on January 17, 1948, at the foot of a large gum tree, in loose top soil beneath damp, decaying leaves and bark, where there had once been a fowlyard, about 15–20 feet from a creek. The larva began to pupate within a few days, but failed to shed the larval skin, and was dead and slightly mouldy within ten days with pupation not completed. It was probably injured in collecting.

Material used in the preparation of this paper consists of one pinned imago ♀ with pupal exuvia, and one pupa with larval exuvia and six larvae, in spirit, all received, together with records, from Miss V. Irwin Smith, and also the partly pupated larva

from Pymble. Some of the larvae were in rather poor condition, as they had died and become mouldy before being preserved. Several larvae have been dissected and mounted; so, too, has the last larval exuvia, which was also in bad condition.

Larva (Text-figs 1 to 9).

Measurements of five larvae made soon after collection by Miss Irwin Smith vary from 28 × 3 mm. to 36 × 4 mm.; two of these were killed at once, and the others (two of the larger size) lived for four months or longer, so they were apparently not mature larvae. The Pymble larva, which was mature, was approximately 45 × 5 mm. But size probably has little relation to maturity, for Mackerras (1956) says of the adults: "The series before me shows considerable variation in size. . . ." In her notes on the living larvae Miss Irwin Smith says "they are a dirty browny yellow colour", and "they are thickest in the thoracic region and thinnest at the last three abdominal segments" (Text-figs 1 and 2). This shape is very similar to that of *Ectenopsis*, and in both species the greater thickness of the thorax is not always so noticeable when the larva is killed and preserved.

The larva is circular in cross-section, not flattened at all. The skin is longitudinally striated; the striations can be seen readily with magnification × 20; they are very fine on the first six abdominal segments, slightly coarser on the last two segments and on the thorax; this arrangement is very similar to *Ectenopsis*.

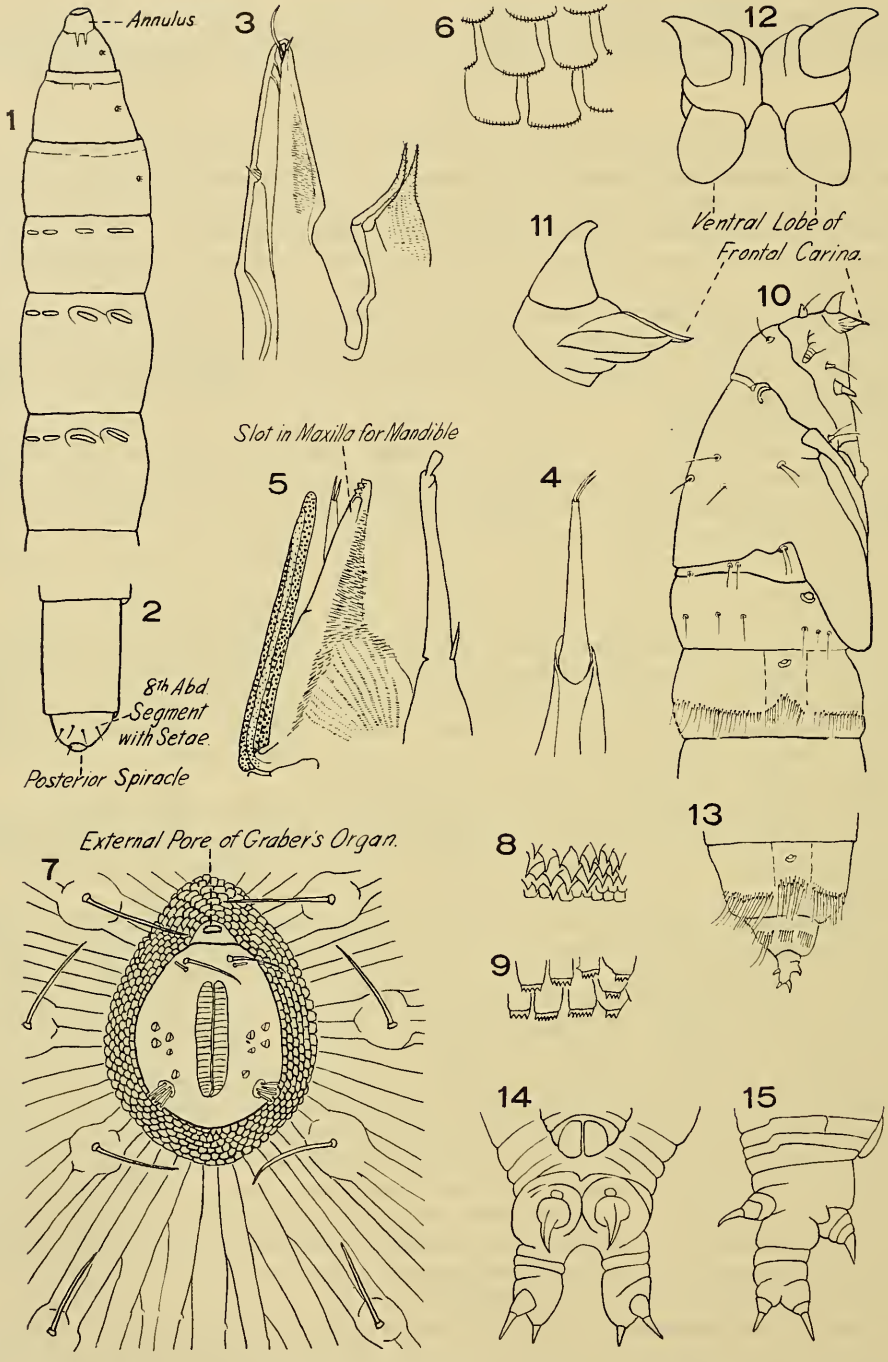
Head. The head capsule is about 4 mm. long; it is slender, and can be completely withdrawn.

The combined clypeus and labrum (Text-fig. 3) is of pale thin chitin. It is long, and tapers to the rounded apex, where there are two long, slender, curved spines set dorsally; other very small processes are present at the apex and on the dorsal edge, and the ventral part is armed with numerous short, fine hairs or spines; the labrum is not differentiated in any way. The labium is much shorter, and terminates in paired, flexible, pointed glossae, which are covered with numerous, closely set, short, fine spines or setae. The labial palps are short and stout.

The antennae (Text-fig. 4) are three-segmented. The basal segment is short, broad at base, and tapering slightly; the middle segment is long, slender, and tapering gradually to the small apical segment which is bifid, the slender branches being more or less equal.

Mandibles and maxillae (Text-fig. 5). The mandibles are long and slender, tapering very slightly to the rounded apex; they are fairly heavily chitinized, brown in colour, with the longitudinal canal opening on the anterior dorsal surface which is characteristic of tabanid larvae, but they lack any serrations on the ventral edge. The maxillae are very lightly chitinized, colourless, transparent and flexible, and they bend back readily when being mounted in balsam. They are broad at base and for part of the length, then narrow sharply and taper to the apex. The upper part is recessed to form a slot for the shorter mandible; the ventral edge is armed with long, slender spines, above which are slightly larger spines extending back; and most of the broad base is covered with numerous rows of very small, closely set setae or spines. The apex (anterior to the slot) is armed with very short, broad-based, pointed spines, with points directed upwards. The maxillary palp is three-segmented; the basal segment short, broad at base, and tapering, with a slender ventral seta; the middle segment long, slender, and tapering to the small apical segment, which is short and rounded at t'ie apex. No piercing spines could be detected.

Thorax. The prothorax (Text-fig. 1) is encircled anteriorly by a wide collar or annulus of small scales, and this is continued back in small points, two on each side; the scales are each armed at the posterior edge with numerous, fine spines visible with low power in slide mounts (Text-fig. 6). At the anterior edge of meso- and metathorax is a narrow band of small scales, some of which are similarly armed. On the dorsal surface of the prothorax, immediately posterior to the annulus, are about ten small, transparent setae; other smaller setae are placed irregularly among the striae on the three thoracic segments; also on each segment are two groups of small setae repre-



Text-figures 1-15. *Caenoprosopon trichocerus* (Bigot). 1-9 Larva: 1, Thorax and abdominal segments 1-3, × 5; 2, Abdominal segments 7 and 8, × 5; 3, Clypeus and labrum with labium, × 50; 4, Antenna, × 50; 5, Mandible, maxilla and maxillary palp, × 50; 6, Scales of annulus of prothorax, × 150; 7, Posterior spiracle and surrounding processes, × 50; 8, Scales of spiracular ring, × 150; 9, Scales of ring round anal papilla, × 150. 10-15, Pupa: 10, Anterior end, × 5; 11, Frontal carina, lateral view, × 25; 12, Frontal carina, end view, × 25; 13, Posterior end, × 5; 14, Aster, ventral view, × 25; 15, Aster, lateral view, × 25.

Note.—The magnifications should be taken as approximate only, because the size of mature larvae and of pupae varies considerably.

senting the prolegs of other larvae. All these setae are visible in slides with low power. At the posterior edge of the prothorax, and near the anterior border of the metathorax, are the small apertures of the thoracic spiracles.

Abdomen (Text-figs 1 and 2). On segments 1 to 5 there is a ring of abdominal pseudopods: two dorsal, long and low; two ventral, short and low; and on each side two higher, more or less rounded mounds, very prominent on segments 3 to 5. On the pseudopods, and at the junction of the segments, the skin has a network pattern; elsewhere it is striated, and among the striae are isolated, single, small setae or hairs as on the thorax. Segment 8 bears the posterior spiracle and anal papilla. The posterior spiracle (Text-fig. 7) is of typical tabanid form. Just dorsal to the aperture, on the spiracular area, are two long and two short hairs; laterally there are very small, mushroom-shaped structures, about five on each side; and near the ventral edge on each side is a group of about four hairs. At the dorsal edge of the area is the aperture of Graber's organ. Surrounding the whole area is a band, more or less uniform in width, of very small scales of variable shapes, some with two points, some with one, and some without points (Text-fig. 8); the shape is visible only in slides, with high power. The anal papilla on the ventral surface is surrounded with an irregular ring of scales, mostly armed with spines (some as in Text-fig. 9). Among the striae on this segment are four pairs of long, slender hairs (Text-figs 2 and 7), readily visible with a hand lens.

PUPA (Text-figs 10 to 15).

This description is based on one ♀ pupal exuvia, length 24 mm., width on first abdominal segment 5 mm., and on one rather shrunken pupa in spirit.

Head and *thorax* (Text-fig. 10). The head bears a large and prominent carinate tubercle (Text-figs 11 and 12) unlike any seen before. It has a pair of large dorsal arms, broad at base, curved, and tapering to a point, and a pair of ventral arms, with apical half more or less flattened, and rounded at the extremity; the four arms are set on a wide rounded base. The anterior orbital seta is long and slender and is set just below the apex of a small triangular tubercle; the posterior orbital seta is very long and slender and is set on the posterior edge of a large, broad based, tapering tubercle, about mid-way between base and apex; the frontal seta is long and slender and is set on the side of a high, tapering tubercle. The vertical seta is long and slender and is set on a small, low mound. The two lateral setae on each side are set together on a small high mound. The antennal sheath reaches almost to the coronal suture, and there is a very small, conical tubercle on the basal segment. The sheath of the proboscis terminates in an almost circular mound topped with a longitudinal ridge.

The thorax bears three pairs of dorsal setae, and on each side there are two alar setae; all are long and slender, and not on tubercles. The thoracic spiracle has a wide rima, almost semi-circular in shape, with the posterior arm extended a little, and the concave side of the rima towards the ventral surface of the pupa. The spiracular pit is separated from the spiracular mound by a small, low mound with a ridged surface. The metathorax bears three pairs of dorsal setae and paired lateral setae; all are long and slender.

Abdomen (Text-figs 10 and 13). The first abdominal segment bears three pairs of tergal setae, not on tubercles, and on each side are three pleural setae, each on a very small tubercle; all setae are long and slender; the spiracular mound is large, with a wide, semi-circular rima. On tergites 2–7 there are strong setae in two, more or less regular rows, with irregularly placed setae between the rows; on tergite 2 the setae are mostly short and very short in the anterior row, mostly long and very long in the posterior row, and between the rows are a few widely spaced long setae; on each succeeding tergite the setae increase slightly in length, they become more closely set in anterior and posterior rows, and more numerous between the rows. On the sternites, the arrangement of setae is very similar. It is similar on the pleurae also, except that the irregularly placed setae between the rows are more numerous. The spiracles on these segments have a wide, semi-circular rima; the spiracular mound and the rima decrease in size gradually from segments 2 to 7.

On the 8th segment, each dorso-lateral comb has about eight setae, two very long, the remainder long and short; each lateral comb has about six short setae; each ventral comb has about six setae, long and short, and these combs are separated in the female by a bare space. The segment terminates in an aster (Text-figs 14 and 15) of unusual shape. It has six arms; the two dorsal and two ventral each have a rounded base with a terminating spine; the two lateral arms are unusual, each consisting of a long column, with more or less parallel sides, terminating in two spines, a larger ventral and a smaller dorsal one.

The material used in the preparation of this paper, i.e., one adult fly with pupal exuvia, one pupa and larvae in spirit, together with slide mounts of dissected larvae and larval exuvia, have been deposited in the Macleay Museum at the University of Sydney.

Discussion.

Besides the larva and pupa of *Caenoprosopon trichocerus* (Bigot), described in this paper, the immature stages of the following species of Pangoniinae have been described: *Goniops chrysocoma* O.S. (Hart, 1895; McAtee, 1911), *Scaptia patula* (Walk.) (Fuller, 1936) (described as *S. auriflua* Don.), *Ectenopsis angusta* (Macq.) (English, 1952), *Scaptia vicina* (Taylor) and *S. muscula* Eng. (English, 1954).

I have been given larvae and pupae of *Goniops chrysocoma*, and loaned larvae and pupae of *Scaptia patula*, and a pupal exuvia of *Scaptia adrel* (Walk.) from New Zealand, so have been able to compare characters in the actual specimens.

The larvae run down to the family Tabanidae in the latest obtainable key of Diptera larvae (Peterson, 1951) and, from descriptions and with the material available, a tentative key has been drawn up for the larvae of the subfamily Pangoniinae, the tribes and the two genera.

Key to Larvae.

1. The eighth abdominal segment bears processes outside the spiracular area and the annulus of the prothorax is covered with small scales armed with spines on the posterior edge ..... Subfamily Pangoniinae 2.
   The eighth abdominal segment does not bear processes outside the spiracular area and the annulus of the prothorax is covered with fine setulae ..... Subfamilies Chrysopinae and Tabaninae.
2. Larva long and slender, white or creamy colour, abdominal segment 7 about twice as long as wide. The body shortens very little when larva contracts ..... Tribe Pangoniini. 3.
   Larva stout, dark in colour or with pigment pattern under skin, abdominal segment 7 about twice as wide as long. The body shortens greatly when larva contracts .. Tribe Scionini.
3. Abdominal segment 8 bears eight stout hairs outside the spiracular area, and on the area dorsal to the spiracular slit are two stout hairs ..... Genus *Caenoprosopon.*
   Abdominal segment 8 bears four slender, tapering, flexible processes outside the spiracular area, and on the area dorsal to the spiracular slit is a single tapering process ..... Genus *Ectenopsis.*

All characters in the key are visible with a hand lens, except the covering of the prothorax which can be seen satisfactorily only in slide mounts with high power. Other differences between the two species can be found in mounted dissections of the head capsule: in *Caenoprosopon trichocerus* the apex of the maxilla is armed with small spines and the second segment of the antenna is almost as long as the second segment of the maxillary palp; in *Ectenopsis vulpecula* the apex of the maxilla is unarmed and the second segment of the antenna is less than half as long as the second segment of the maxillary palp.

The pupae present a much more difficult problem, for there do not appear to be any characters to distinguish the subfamily and only the Pangoniini can be grouped as a tribe on similar characters. One character only, three pairs of setae on the dorsum of the thorax, occurs in all the species listed above, and it is unsatisfactory as a subfamily character for two reasons: (*a*) in *Goniops* and in the three Australian species of *Scaptia* these setae are very fragile and are frequently broken off, leaving no trace, and (*b*) the same character occurs in at least two species of the tribe Rhinomyzini subfamily Chrysopinae.

Pupae of the tribe Pangoniini can be distinguished by paired lateral setae, long and slender, on the metathorax, and paired alar setae, long and slender on the thorax. No other pupae known to me bear paired lateral setae on the metathorax and only in species of *Chrysops* are there paired alar setae, these being very small and fragile. The posterior orbital seta on the characteristic thorn-like tubercle may be another tribal character, but it is not very useful because so often the head shield is lost. For the tribe Scionini distinguishing generic characters may be: for *Scaptia*, a second mound, large or small, between the thoracic spiracular mound and the spiracular pit, and the rima of the spiracle is a very small semi-circle; for *Goniops*, on the dorsal edge of the thoracic spiracular mound, is an excavated channel running down to the spiracular pit almost immediately below.

Except in *Caenoprosopon trichocerus*, where there is a very small secondary thoracic mound, no other tabanid pupae known to me have these characters.

Pupae of the two species of Pangoniini can be distinguished most readily by the frontal carina and by the aster on the eighth abdominal segment, though there are other differences. In *Caenoprosopon trichocerus* the frontal carina has four arms, the thoracic setae are not on tubercles, the abdominal spiracular mounds are wide-based and low and the large wide rima covers about half the surface of the mound, the middle arms of the aster are much larger than the others and each bears two terminal thorns or spines. In *Ectenopsis vulpecula* the frontal carina has two arms, the thoracic setae are set on small tubercles, the abdominal spiracular mounds are small-based and high and the small wide rima covers almost all the apical surface of the mound, the arms of the aster are more or less equal in size and each bears a long seta.

With larvae and pupae of so few species available the characters for determining the subfamily and the tribes are suggested tentatively; they may not hold when other specimens are found.

A striking result of these investigations was the finding that there are such definite characters for grouping the larvae in the subfamily and the tribes, and such a lack of distinguishing characters for grouping the pupae.

Does this mean that the larvae have retained their primitive characters in spite of changes in environment whilst the pupae, or some of them at any rate, have made structural changes in adapting themselves to different environments?

This is quite possible, for the larvae are mainly carnivorous and would not be much affected by changed conditions, they would live on other creatures whatever the environment, whilst the pupae must adapt themselves to survive in and to emerge from the very varied media in different environments.

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